I. C. 7055 FEBRUARY 1939

UNITED STATES
DEPARTMENT OF THE INTERIOR
HAROLD L. ICKES, SECRETARY

BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

INFORMATION CIRCULAR

ANNUAL REPORT OF THE MINING DIVISION, FISCAL YEAR 1938

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CHAS. F. JACKSON

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INFORMATION CIRCULAR

UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

ANNUAL REPORT OF THE MINING DIVISION, FISCAL YEAR 1938[1]

By Chas. F. Jackson[2]

INTRODUCTION

The annual reports of the supervising engineers of the seven sections comprising the Mining Division are assembled in the following pages and form the annual report of the division.

In planning activities, the aim has been to adapt the work to changing conditions and needs of the mining industries and to avoid becoming bound to any particular type of investigation when others are found to be of more pressing interest.

Thus, when public requests multiplied for investigation of mining activities in various counties or districts in the Western States and for technical assistance to prospectors and small-scale operators financially unable to employ competent engineers, the emphasis was put upon this type of work by the Metal-Mining Methods Section, which for some years had been engaged principally upon a study of mining and milling methods, practices, and costs. In addition, a Mineral-Industries Survey Section was established to survey selected districts of special promise. When requests for information on gold mining and milling began to predominate, the emphasis was shifted from work at base metal mines to gold mining. With greater need for accurate scientific information as to the effects upon buildings of earth tremors induced by blasting in mines and quarries, the Nonmetal Mining Section, which for several years had been devising and perfecting instruments for accurately measuring earth movements caused by blasting, undertook this as a major problem.

Many of our older mines are reaching depths at which the greater rock pressures encountered require that mining operations be conducted with greater care to prevent rock bursts and disastrous caving. First mining has been completed at other mines, and the problem of safe extraction of as large a percentage as possible of the ore left in pillars is presented. These problems could be solved more readily if scientific but practical methods of determining actual pressures and stresses in the rocks in each stope or section of a mine could be developed. For 2 years the

1/ The Bureau of Mines will welcome reprinting of this paper provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7055."

2/ Chief engineer, Mining Division, Bureau of Mines.

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Metal-Mining Research Section has been searching for a method of solving the problem that is most likely to be successful. Although the work has been done with limited funds and the help of part-time consulting physicists only some promising avenues of approach have been opened, and some new apparatus designed and built. Recently, the need for this work has been emphasized by operators in two districts in this country, and with the beginning of the fiscal year 1939 a full-time physicist will be assigned to the problem.

Ventilation and cooling of mine air are becoming more and more vital, both from a health and safety and an economic standpoint, as our mines become deeper, and the Mine-Ventilation Section is now majoring in air-conditioning of mines.

With greater mechanization of mining operations, new mechanical hazards in working have arisen, so that the field of the Electrical-Mechanical Section has been expanded to include investigations designed to increase safety and efficiency in operating mechanical equipment.

With recent rapid changes in coal-mining practices, methods, and equipment has come the need for detailed investigation of special problems and new methods. The Coal-Mining Section, therefore, has been concentrating on strip-coal mining, especially rail v. motorized haulage, and on multiple-shift mechanized underground mining.

Work on the foregoing and other special problems is summarized in the reports of the several section supervisors.

The investigation of mining and milling methods, practices, and costs remains a back log for the division's work, and operating engineers throughout the country continue to favor strongly the issuance of additional publications on operations at individual mines and plants and of summary papers dealing with the various phases of mine operation. During the past year considerable progress was made in the Washington office on assembling within one volume the important data and discussions embodied in over 200 earlier publications dealing with these subjects.

The work of the division is directed from the Washington office. The section supervisors, however, are encouraged to use their own judgment in initiating and conducting investigations in their fields and to keep in close touch with the industry to determine better where the emphasis should be placed in their work. Suggestions from mine operators regarding the type of work they consider most useful are earnestly sought. The chief engineer of the division spends as much time in the field as other duties will permit and usually visits and studies mines in three or four sections of the country each year.

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Reports of the various sections follow:

METAL-MINING METHODS SECTION

E. D. Gardner, Supervising Engineer

For several years the work of the Metal-Mining Methods Section has been devoted largely to a study of mining and milling methods, practices, and costs in the Western States. During the past year most of these studies were made by counties or districts.

During the year 22 information circulars and one bulletin were printed; 6 await publication. One information circular awaits release by the company concerned.

Two information circulars and excerpts from a bulletin were reprinted in other publications. Three information circulars were printed in installments in Nevada newspapers.

Metal-Mining Methods in Western States

In cooperation with mining-company officials, a series of papers has been published on mining methods and costs at a large number of important and representative mines. A single outline has been used for all of these papers; the data presented from the operators' viewpoint are in comparable form and represent a wide range of conditions. The industry at large has benefited from the pooled information in these papers; many operators have found suggestions for improving individual practices.

During the current fiscal year the following papers were published:

I.C. 6945 - Mining and Milling Methods at the Pilgrim Mine, Chloride, Ariz., by Earl F. Hastings. 18 pp.3/

I.C. 6947 - Mining and Milling Methods and Costs at the Golden Messenger Mine of the United Gold Mines Corporation, York, Mont., by S. H. Lorain. 14 pp.

I.C. 6950 - Mining and Reduction Methods and Costs at the Oceanic Quicksilver Mine, Cambria, San Luis Obispo County, Calif., by A. W. Frolli. 13 pp.

I.C. 6960 - Sampling and Testing of a Gold-Scheelite Placer Deposit in the Mojave Desert, Kern and San Bernardino Counties, Calif., by H. W. C. Prommel. 18 pp.

I.C. 6961 - Placer Operations of Humphreys Gold Corporation, Clear Creek, Colo., by E. D. Gardner and Jos. R. Guiteras. 16 pp.

I.C. 6963 - Mining Methods and Costs of the Quartz Hill Mining Co., Dewey, Mont., by S. H. Lorain. 17 pp.

3/ Shown as being published fiscal year 1937 in Information Circular 6973.

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I.C. 6976 - Operations and Costs at the St. Joe Mining & Milling Co., Boulder, Colo., by Jos. R. Guiteras. 34 pp.

I.C. 6978 - Mining Methods and Costs at the Mount Isa Mines, Ltd., Queensland, Australia, by J. Kruttschnitt and V. I. Mann. 35 pp.

I.C. 6985 - Gold Mining and Milling Methods and Costs at the Gold Hill Mine of Talache Mines, Inc., Quartzburg, Idaho, by Joe H. Skidmore. 15 pp.

I.C. 7003 - Mining Methods and Costs at the Judge Mine, Park City, Utah, by Geo. S. Krueger and E. A. Hewitt. 10 pp.

The following papers are in press:

I.C. 7029 - Cost of Mining 55 Tons of Copper-Nickel Ore at the Great Eastern Prospect, Bunkerville, Clark County, Nev., by Paul T. Allsman.

I.C. 7024 - Mining and Milling Methods and Costs of the Golden Anchor Mining Co., Burgdorf, Idaho, by W. Buford Davis and S. H. Lorain.

I.C. 6990 - Mining and Milling Methods and Costs at the Summitville Consolidated Mines, Inc., Summitville, Colo., by Jos. R. Guiteras.

Metal-Mining Methods and Costs, Summaries

A mass of useful information has been accumulated in the information circulars on mining methods and costs and milling methods and costs. Moreover, considerable data have been collected at mines and mills, which have not been used in individual papers.

Summary papers based upon assembled data and augmented by special field investigations have been published, which embrace the results of studies of principal underground mining methods and various phases of mining and milling operations. They also include studies of the mining of gold, lead, and zinc ores and the milling of copper ores. A bulletin on open-cut mining was partl prepared during the year, and a bulletin on Copper Mining in North America was off press in June 1938. Papers on three general phases of mining were published.

Work is nearing completion on a bulletin dealing with methods and costs of developing, equipping, and operating small gold mines and mills. A wide range of conditions affecting these small-scale operations is discussed in t paper; it is intended to serve as a general guide for prospectors, operators and engineers and for those who contemplate entering the gold-mining field.

During the fiscal year the following papers of this series were publish

I.C. 6943 - The Design of Small Wooden Headframes, by W. W. Staley. 37 pp.4/

4/ Included in I.C. 6973 as being published in 1937 but not previously reported by this station.

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I.C. 6948 - Aerial Tramways in the Metal-Mining Industry, Part 1, by O. H. Metzger. 32 pp.

I.C. 6982 - Pumping Operations in the Cripple Creek District, Colorado, by Jos. R. Guiteras. 14 pp.

I.C. 7013 - Power-Shovel and Dragline Placer Mining, by E. D. Gardner and Paul T. Allsman. 68 pp.

Bulletin 405 - Copper Mining in North America, by E. D. Gardner, C. H. Johnson, and B. S. Butler. 300 pp.

Milling Methods and Costs, Western States

The study of milling methods and costs is carried on concurrently with the one on mining methods and costs. The work has a similar objective - to pool information so as to promote the use of the best practices at individual plants and the conservation of mineral resources.

The following papers were published during the year:

I.C. 6945 - Mining and Milling Methods at the Pilgrim Mine, Chloride, Ariz., by Earl F. Hastings. 18 pp.

I.C. 6947 - Mining and Milling Methods and Costs at the Golden Messenger Mine of the United Gold Mines Corporation, York, Mont., by S. H. Lorain. 14 pp.

I.C. 6975 - Milling Methods and Costs at the Mill of the Tom Reed Gold Mines Co., Oatman, Ariz., by Paris V. Brough. 25 pp.

I.C. 6976 - Operations and Costs at the St. Joe Mining & Milling Co., Boulder, Colo., by Jos. R. Guiteras. 34 pp.

I.C. 6985 - Gold Mining and Milling Methods and Costs at the Gold Hill Mine of Talache Mines, Inc., Quartzburg, Idaho, by Joe H. Skidmore. 15 pp.

I.C. 7012 - Milling Methods and Costs of the Cardinal Gold Mining Co., Bishop Creek, Calif., by Walter B. Lenhart. 22 pp.

The following papers are in press:

I.C. 7024 - Mining and Milling Methods and Costs of the Golden Anchor Mining Co., Burgdorf, Idaho, by W. Buford Davis and S. H. Lorain.

I.C. 6990 - Mining and Milling Methods and Costs at the Summitville Consolidated Mines, Inc., Summitville, Colo. by Jos. R. Guiteras.

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Mineral Industries Survey

To meet requests from various States, the chief work of the Mining Methods Section during the fiscal year was making mining surveys of counties or districts. Following the field surveys, papers describing the mines and mills, types of ore deposits, and the general geology are prepared for publication. They contain discussions of mining and milling methods, practices, and costs; haulage, freight, ore-treatment, and power costs; availability of water, timber, and labor; and climate and topography.

A paper on Gold Mining and Milling in New Mexico has been published. Mining and milling in Nevada are being described by counties; up to the end of the current year, four Nevada county reports have been published, one is in press, and one is in the course of preparation. This survey will be continued until all of the counties of the State have been discussed.

Papers on placer mining in two counties and a paper on lode mining in one county in Idaho are in press. At the end of the year, an investigation of all types of mining and of the mineral resources of the western counties of South Dakota was begun. Information circulars on three mining districts in Arizona, one in Montana, and one in Oregon have been published.

The district and county papers contain descriptions of small operations of merit but not of sufficient importance to justify individual papers. These descriptions are of especial interest to small-scale operators. The papers, on the whole, are of value to prospective investors and companies that contemplate beginning work in any of the areas described. They contain preliminary data required by engineers for estimating costs, determining ore reserves, and opening closed mines.

The following papers were published during the year:

I.C. 6964 - Reconnaissance of Mining Districts in Clark County, Nev., by William O. Vanderburg. 81 pp.

I.C. 6972 - Gold Lode Mining in the Tobacco Root Mountains, Madison County, Mont., by S. H. Lorain. 74 pp.

I.C. 6987 - Gold Mining in New Mexico, by O. H. Metzger. 71 pp.

I.C. 6991 - Gold Mining and Milling in the Wickenburg Area, Maricopa and Yavapai Counties, Ariz., by O. H. Metzger. 78 pp.

I.C. 6995 - Reconnaissance of Mining Districts in Humboldt County, Nev. by William O. Vanderburg. 54 pp.

I.C. 7015 - Gold Mining and Milling in Northeastern Oregon, by S. H. Lorain. 46 pp.

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The following papers are in press:

I.C. 7022 - Reconnaissance of Mining Districts in Eureka County, Nev., by William O. Vanderburg.

I.C. 7023 - Reconnaissance of Placer-Mining Districts in Idaho County, Idaho, by S. H. Lorain and O. H. Metzger.

I.C. 7028 - Reconnaissance of Placer Mining in Boise County, Idaho, by O. H. Metzger.

General

An important part of the duties of engineers in the field is to assist small-scale operators and prospectors financially unable to employ competent technical advice. Such assistance is given only upon request. If it appears that the operator can afford to employ necessary technical assistance, the engineers of the Bureau refer the operator to competent consultants, the policy being to recommend at least three if possible, preferably men from the district or State in which the property is situated.

The field offices answer many inquiries from individuals desiring information on mining or allied subjects. A file is kept of inquiries for minerals and mineral deposits and of owners of deposits who call or write requesting information regarding markets and buyers for their properties. Most inquiries made during the year concerned placer gold and the rare metals or minerals. A number of owners of deposits were put in touch with prospective buyers.

METAL-MINING RESEARCH SECTION

McHenry Mosier, Supervising Engineer

This section is carrying on two types of investigations - (1) the assembling and dissemination of information on improved mining practice developed at individual mines and (2) independent original research.

Concerning the first type, there was published Information Circular 6979, Electric Signaling System, Ross Shaft, Homestake Mining Co., by John F. Wiggert, December 1937, 7 pp. The field work on three other problems of this type was completed. The first of these was an investigation of mechanical shoveling in underground metal mines. Many mining districts of the Middle Western and Far Western States were visited. The outstanding development in recent years is the introduction of the small mine-car loader of the nonrevolving beltless type with tractive thrust and dipper travel in a vertical arc.

Another was the study of open-pit mining in the United States. In the Lake Superior mining district the introduction of belt conveyors with automobile trucks and tower excavators for assembling the ore in the pit has improved the technique in iron mining.

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The third problem was a study of operations at the Haile Gold Mines, Inc., Kershaw, S. Car., upon which will be based a report for publication. This plant, which is the largest in the Appalachians, illustrates the value of adequately financing gold mines, particularly in this region.

In addition, an investigation of the use and care of wire ropes for hoisting in mine shafts was undertaken to bring up to date earlier publications of the Bureau.5/ Data obtained from several of the leading manufacturers of wire ropes and from some of the mining companies employing advanced practices show the value of thorough lubrication and careful inspection of ropes in service. Some of the newer methods proposed for inspection, such as the magnetic and electrical systems, are impractical of application at this stage of their development.

A study of problems of the second type, involving independent original research by engineers of the Bureau of Mines, has been emphasized during the past year.

One of the principal investigations in this group is the measurement of pressures on underground rock columns. This research, which was begun in 1936, is recognized to be the first of its kind to take actual measurements of waves induced in rock columns under variable loadings.6/ (See figs. 1 and 2.)

The determination, in the laboratory by the sonic method, of the changes in the modulus of elasticity of small rock columns subjected to increasing pressures has encouraged the belief that a practical method of measuring such pressures on rock in place can be developed. Many operators of metal mines have expressed active interest in this problem. It is important to underground mines, both for the safety of miners and for the recovery of a larger proportion of ore.

Testing Adit at Mount Weather

The Testing Adit at Mount Weather, Va., established by the Bureau of Mines in 1936, provides the means for conducting investigations on many problems involving original research on the fundamentals of mining. Operations were continuous throughout the year. A uniformly hard, dense basalt is exposed at the face of the main heading, which is eminently suitable for tests on rock drilling and for studies in blasting. The equipment and facilities at Mount Weather have permitted the following schedule of active investigations:

Use of Detachable Rock-Drill Bits Fabricated from Alloy Steels

A study of various alloy steels showed that bits forged from one alloy drilled 70 percent farther and 19 percent faster than straight carbon-steel bits. The loss of gage was reduced 43 percent. Although bit breakage was hi the results indicate favorable possibilities for bits made from this alloy.

5/ Ingalls, W. R., and others, Rules and Regulations for Metal Mines: Burea of Mines Bull. 75, 1915, 296 pp.
Hood, O. P., and Kudlich, R. H., Safe Practice in Using Wire Ropes in Mi Bureau of Mines Tech. Pap. 237, 1919, 11 pp.

6/ Weiss, Oscar, The Theory of Rock Bursts and the Possibilities of Geophysic Methods in Predicting Rock Bursts on the Producing Mines of the Witwaters rand: Jour. of the Chem., Met. and Min. Soc. of South Africa, January 1

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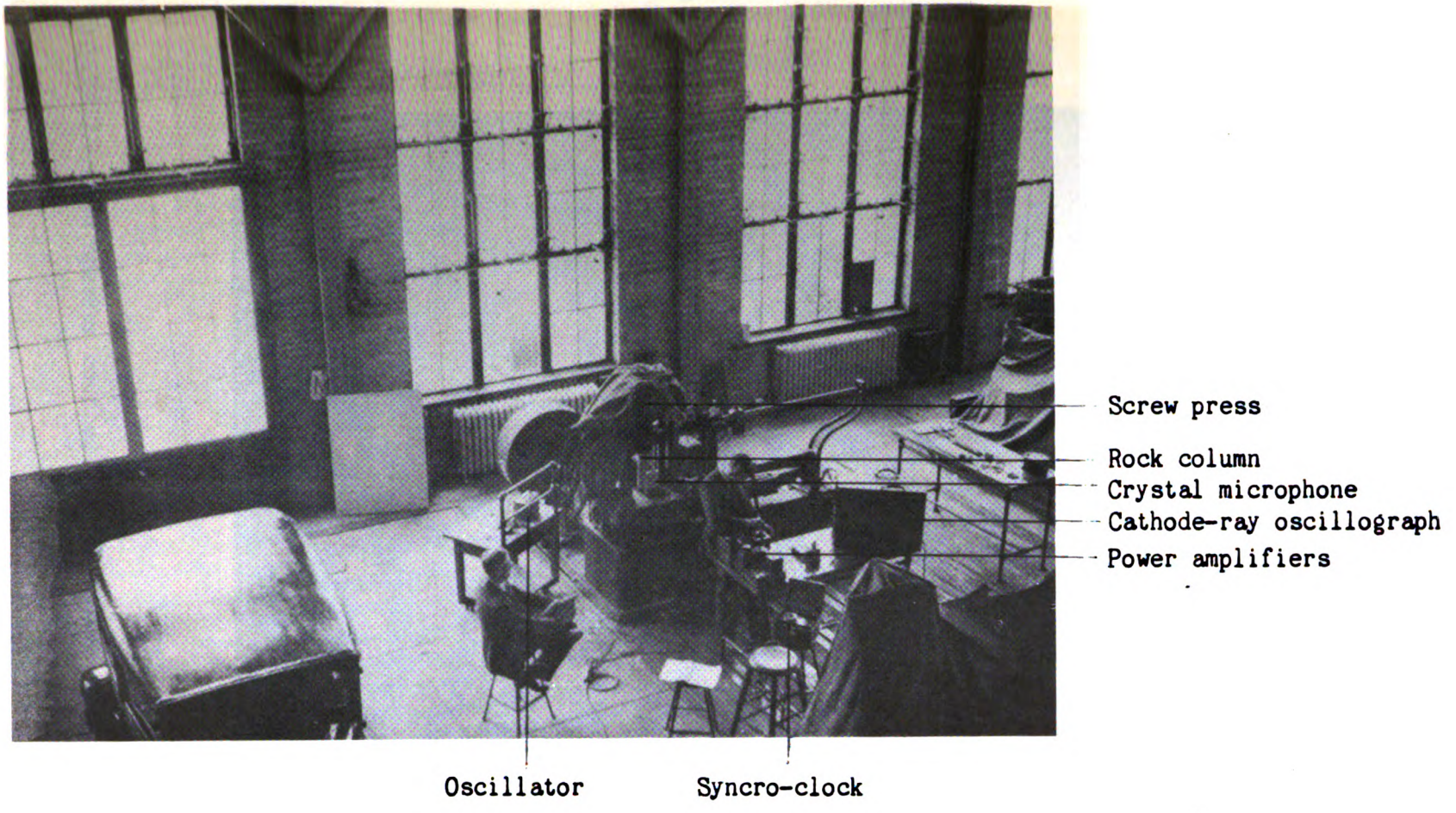

Figure 1.- General set-up of equipment in laboratory.

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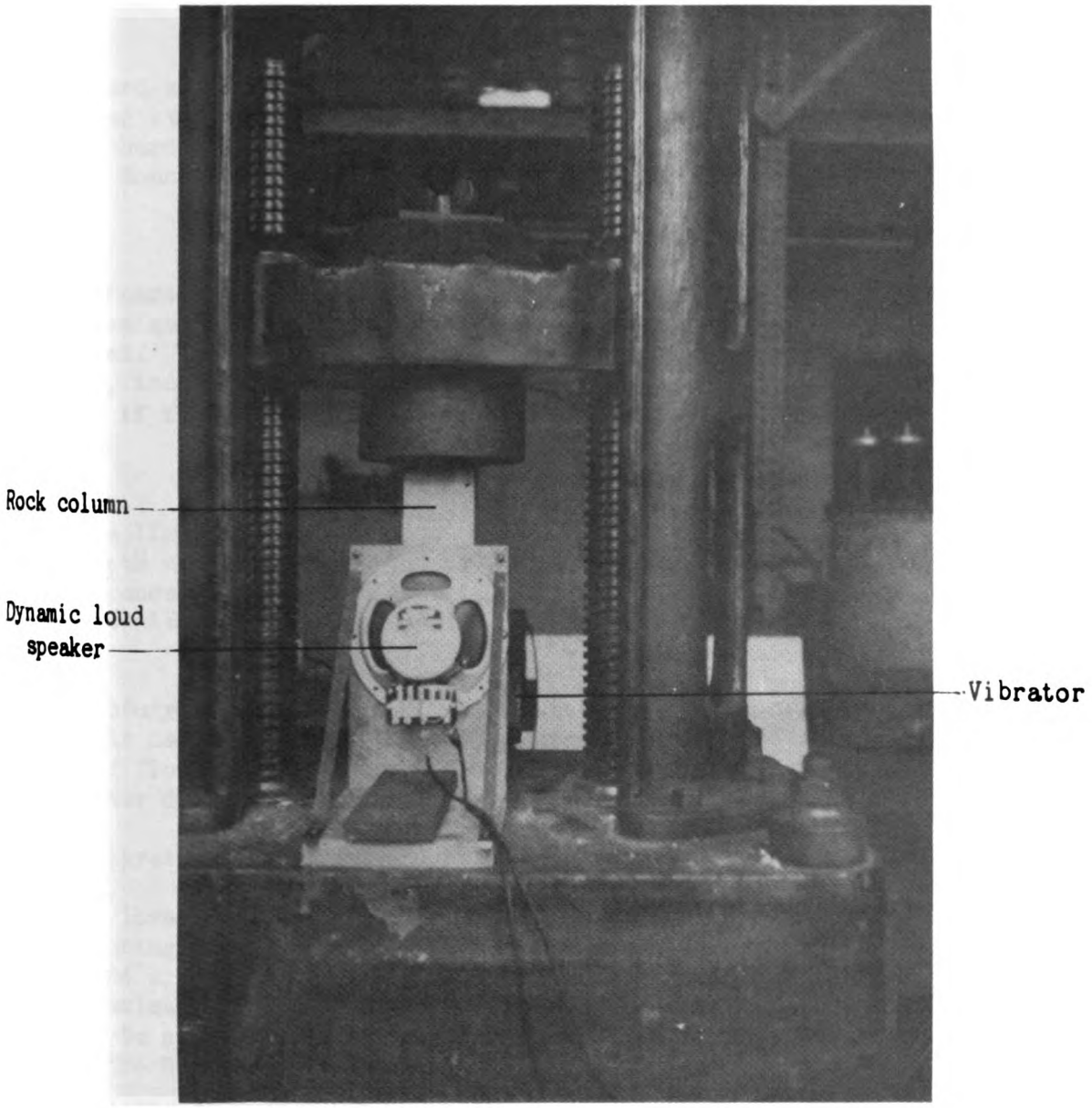

Figure 2.- Loud speaker coupled to rock column in screw press.

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Alloy-Steel Drill Rods

Drill rods of a special steel are undergoing tests in actual drilling operations, but the work has not proceeded far enough to be conclusive.

Hard-Surfaced Detachable Rock-Drill Bits

The hard-surfaced bits tested drilled farther and faster with less loss in gage than straight carbon-steel bits. Because of their brittleness, breakage of the hard-surfaced bits was excessive under the severe drilling conditions at Mount Weather.

Full-Reaming Bits

Full-reaming bits drilled 20.4 percent faster than nonreaming bits of the same nominal gage and they lost only 35 percent as much gage per foot of hole drilled. These results, although applying specifically to Mount Weather conditions, indicate the possibilities for increased drilling efficiency at many mines if full-reaming bits are adopted.

Dust Studies

From a limited study at Mount Weather of the relation of dust concentration to depth of hole during wet drilling, it has been established definitely that dust concentration decreases rapidly with increased depth of hole. Most of the dust dispersed into the air comes from the first foot or two of each hole. 7/

In a study of the effect of sharpness of bit on dustiness during wet drilling, it developed that sharp bits produce more dust than dull bits when the rate of flow of water through the drill steel remains constant because of the faster drilling rate with sharp bits. 8/

Vibration of Ground and Buildings from Underground Blasting

In an investigation of the vibration of ground and buildings from underground blasting, the explosion of 208 pounds of 40-percent nitrostarch in an 8-foot round produced a maximum movement of the ground at the surface of 0.06 inch and maximum movement of a building over the adit of 0.10 inch. This was enough to crack old embrittled plaster. For further details refer to the report of the Nonmetal Mining Section, which follows.

7/ Littlefield, J. B., and Schrenk, H. H., Relation of Dust Concentration to Depth of Hole During Wet Drilling: Bureau of Mines Rept. of Investigations 3369, 1938, 5 pp.

8/ Harrington, D., Some of the Results of Recent Research on the Control or Prevention of Silicosis: Bureau of Mines Inf. Circ. 6994, February 1938, 8 pp.

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Other Investigations

Other investigations for which the procedure has been planned in detail and on which work has been begun are ventilation of headings, stemming of drill holes, comparative drilling speeds of a drifter with anvil block and with standard construction, long rounds for small headings, effect of bit size upon rock-drilling speed, and noxious gases from blasting underground.

NONMETAL MINING SECTION

J. R. Thoenen, Supervising Engineer

Publications Issued During the Year

By the Bureau of Mines:

I.C. 6962 - Mining and Grinding Methods and Costs at the Malvern Clay Co. Mine, Malvern, Ohio, by E. J. Lintner. 22 pp.

I.C. 6967 - Methods and Costs of Mining and Crushing Gypsum at the Mine of the Victor Plaster, Inc., Victor, N. Y., by E. J. Lintner. 18 pp.

I.C. 6971 - Methods and Costs of Mining and Crushing Gypsum at the Mine of the Ebsary Gypsum Co., Inc., Wheatland, N. Y., by E. J. Lintner. 19 pp. (This publication was withdrawn at the request of the company.)

I.C. 6984 - Mineral Wool, by J. R. Thoenen. 54 pp.

R.I. 3353 - Earth Vibrations Caused by Quarry Blasting. Progress Report by J. R. Thoenen and Stephen L. Windes. 73 pp.

R.I. 3377 - Primary Crushing. Progress Report 1, by Mark Sheppard and C. N. Witherow. 11 pp.

R.I. 3380 - Primary Crushing. Progress Report 2, by Mark Sheppard. 16 p

R.I. 3390 - Primary Crushing. Progress Report 3, by Mark Sheppard. 10 p

Through other agencies:

Sand and Gravel Chapter, Industrial Minerals and Rocks, by J. R. Thoenen Am. Inst. Min. and Met. Eng., 1937.

Measurement of Mechanically Induced Vibrations on a Stucco Residence, by J. R. Thoenen and S. L. Windes: Mimeo. Contrib., Industrial Minerals Divisio Am. Inst. Min. and Met. Eng., 1937.

Hydraulic Stripping at a West Virginia Limestone Quarry, by Mark Sheppar Am. Inst. Min. and Met. Eng. (T.P. 879).

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Earth Vibrations from Quarry Blasting, by J. R. Thoenen: National Crushed Stone Assoc., Cincinnati, Ohio, Jan. 24, 1938. Pub. Crushed Stone Journal, vol. 13, no. 2, March-April 1938.

Seismic Phenomena as Revealed by Quarry Blasting, by J. R. Thoenen and S. L. Windes: Seismic Section, Geophysical Union, April 27, 1938. Trans. Geophysical Union.

Manuscripts completed and awaiting publication:

R.I. 3407 - Earth Vibrations from Mine Blasting. Progress Report 2, by J. R. Thoenen and S. L. Windes.

Sand and Gravel Prospecting, Development, and Excavation, by J. R. Thoenen. (Submitted for publication as a Bulletin.)

House Movement as Caused by Ground Vibration, by J. R. Thoenen. (Submitted for publication in Rock Products Magazine.)

Primary Crushing. Progress Report 4, by Mark Sheppard.

Primary Crushing. Progress Report 5, by Mark Sheppard.

Primary Crushing. Progress Report 6, by Mark Sheppard.

Primary Crushing. Progress Report 7, by Mark Sheppard.

Quarry Drilling and Blasting, by E. J. Lintner. (Technical reports covering 8 quarries.)

Problems

Methods and Costs of Mining and Preparation of Nonmetallic Minerals

The report "Mineral Wool" was completed and published as Information Circular 6984. Further field work is planned, and a supplementary report may be published in 1939.

Drilling and Blasting Practice in Quarries

A study of drilling and blasting practices in quarries was begun with the hope of discovering methods by which current practices might be improved. Several months were spent in studying existing literature on the subject preliminary to making field investigations. These were begun during the year; several quarries were visited, and detailed time studies were made.

The speed of drilling alone is not a true measure for comparing efficiency of drilling at various quarries because of differences in the "drillability" of the rocks. Likewise, blasting efficiencies at different quarries cannot be compared rationally, unless allowance is made for the

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differences in toughness and other characteristics of the rock, such as natural planes of weakness and their prominence, direction, and frequency of occurrence. Consideration is therefore being given to devising methods for determining the comparative "drillability" and "breakability" of rock masses.

Related Information

When a quarry is visited for the purpose of studying drilling and blasting, time studies of other quarry operations are made also. In this way a fund of information on current quarry practice is being obtained as a basis for publications on other operating problems.

A third object of this work is to assist quarry operators on technical problems, very few of whom have the funds, time, or personnel for making analytical time studies. A brief summary of the time studies made at each quarry is prepared and returned to the operator; factual data only are given for the present, and the individual operator is left to draw his own conclusions.

Size Gradation of Primary Crusher Feed and Product

This study was continued throughout the year; three progress reports, mentioned at the beginning of this report, have been published and four others have been prepared.

Heretofore it has been necessary to screen samples by hand, which has made the work slow and laborious. Therefore, a portable, knock-down, mechanical shaker has been constructed and fitted with an electric motor drive. This shaker was designed so that it could be carried in the back of a coupe. It was first used in June 1938 and proved entirely satisfactory.

Tests for particle shape were continued by rescreening the products from the square test screens over two sets of elongated mesh screens, the widths of which were, respectively, one-half and one-third that of the corresponding square mesh.

In previous tests, when a car of quarry-run stone was crushed and the product compared with that produced in crushing a carload of lump stone, calculations indicated that had the lump material been scalped from the quarry-run test and crushed separately fewer fines would have been produced. Some question arose as to whether actual scalping would substantiate this theoretical calculation. At one quarry the quarry-run test material was separated into two lots - one run through the crusher and the other scalped. The final results confirmed previous theoretical calculations.

At another quarry similar test feeds were passed through the same crusher set at different discharge openings. No apparent change in the particle-shape distribution was found in the two tests. At this particular quarry, less slabby material was found in the smaller sizes. This is interpreted to reflect the effect of softer stone, since with harder stones the finer products invariably had a larger amount of slabs in the finer sizes.

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At the end of the year it was still impossible to draw any definite conclusions from the study, although some were indicated. A good many more field tests will be required.

Earth and Air Vibrations from Quarry Blasting

Efforts were concentrated on improving the accuracy of test apparatus and field technique, and considerable time was consumed at headquarters in analyzing and interpreting field tests made during the previous year.

Two progress reports were prepared for publication by the Bureau and one was issued. The second was in course of printing at the end of the year.

At the beginning of the year, many field data had been accumulated giving much information regarding the characteristics of ground vibrations. Those data have been only partly interpreted and it is felt that more study is necessary before quarry tests are resumed.

Tests designed to damage buildings deliberately by vibrations from blasting have been delayed because of the difficulty experienced in obtaining the use of suitable structures so situated that damage would not result to adjacent or near-by permanent structures also.

Mount Weather Tests

Tests were run on the office at the Mount Weather Testing Adit, in which explosive charges, increasing in weight by increments, were detonated in the adit below the office. With a maximum charge of 195 pounds of explosive, the plaster in the ceiling of one room was cracked. The distance between shot and ceiling was 95 feet, and the movement of the ceiling was roughly 0.09 inch. This test to a certain degree established a measure of destructiveness for ground vibrations, but it applies only to the particular conditions of the test. Further tests with new plaster will be made soon.

An explosives manufacturer prepared and furnished four explosive mixtures of different physical characteristics. These were tested at Mount Weather to ascertain the effect of the differences upon resulting earth vibrations. At the end of the year these tests were incomplete, but indications were that the vibrational effect differed markedly with different explosives.

Interpretations of tests made in a limestone mine show conclusively that under identical conditions test records can be repeated accurately, even to actual photographic wave shape. This suggested an intensive study of wave shapes, which was begun but has not been completed. The study showed, however, that a shot in any particular location produced a characteristic wave shape. It showed also that two shots at the same place, but one delayed a fraction of a second, produced entirely different wave shapes. This delayed-shot wave shape, however, can be demonstrated mathematically to be the resultant of two characteristic waves spaced at the time interval of the shots and added together. This led to tests at Mount Weather to determine if two shots could

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be so timed that the vibration from one could be erased by those from the second. These tests have not been completed but indicate some interesting possibilities.

Attempts were made, also, to cause measurable damage by pendulum impacts to the house at Mount Weather. A 450-pound weight on a 14-foot radius swung from various arcs while causing considerable house movement did not cause noticeable damage to plaster.

APPARATUS IMPROVEMENT

The master oscillators previously set up at Lewisburg, Pa., were moved and set up in the laboratory at College Park. Some changes and improvements were made in the electric driving equipment as well as in the oscillators themselves.

A study of the master oscillators has brought to light several deficiencies in the operation of the electrical circuits used in connection with the amplifiers and seismometers. All these have been corrected as they have appeared.

A geoscope was purchased for use in measuring the depth of overburden when records of quarry blasts are made. This instrument was taken into the field near headquarters and the field crew was made familiar with its operation.

The path followed by a particle actuated by vibrations from quarry blasts was analyzed. It was found to be extremely complicated and to extend in three dimensions. Moreover, the path followed by a particle in a building apparently is influenced by the structure itself and differs materially from the path of a particle in the ground. The studies of wave shape and path of motion both hold promise of eventual solution of many of the perplexing anomalies that now interfere with intelligent interpretation of past records.

Requests continue to come to the section for assistance in solving vibration problems. During the past year tests were made for the Navy Department, the Army Engineer Corps, and the National Park Service. Similar requests from private individuals are refused unless in the course of the investigation information directly applicable to the objectives of the research is obtainable.

COAL MINING SECTION

Albert L. Toenges, Supervising Engineer

Technical Report

The Coal Mining Section of the Mining Division investigated two mining subjects of immediate importance and interest during the year - multiple-shift mechanical mining in some bituminous-coal mines and locomotive v. truck haulage in bituminous-coal strip mines.

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Mines are the laboratories of the Coal Mining Section. Field studies are made of coal-mining operations and their various phases with the object of drawing conclusions from these investigations that will tend to increase efficiency and promote conservation and safety in operation.

Multiple-Shift Mechanical Mining in Some Bituminous-Coal Mines

Mining methods and practices were studied at 6 mines in Wyoming, 4 in West Virginia, 1 in Ohio, 2 in Kentucky, 1 in Indiana, and 6 in Alabama.

In general, the types of mechanization investigated comprised:

1. Loading coal into cars with mobile loading machines.
2. Loading coal with mobile loading machines onto conveyors.
3. Hand loading onto conveyors.
4. Loading coal with scrapers.

The purpose of the investigation was to determine, if possible, the feasibility of mining coal mechanically where more than one shift is worked per day, the advantages and disadvantages of the various types of equipment, and the mining systems now in use. The number of mines included in this study was limited, and the investigation will be continued during the coming year. The results of the first investigation were published in Information Circular 7014, Multiple-Shift Mechanical Mining in Some Bituminous-Coal Mines - Progress Report 1. A number of interesting facts were developed. An advantage of continuous flow of coal from face to tipple or central loading point was noted. The necessity of adopting types of loading equipment and mining systems best suited to physical conditions was shown by the operating efficiency at some mines. Multiple shifting has various advantages. It reduces the amount of equipment necessary to produce a given daily tonnage, which should reduce the capital charge per ton. All operations in the cycle of mining follow each other in a definite sequence and for best results should be continuous. Concentration of working places lends itself to closer supervision. Results with every type of mechanization, not only as to output per man but also as to safety of operation, are satisfactory in proportion to the amount of supervision. Where more than one shift is worked, the same supervision should be given on all shifts. Working the third or "graveyard" shift is not believed advisable as the workers' efficiency on this shift is doubtful. Workers are in a much better condition psychologically and physically and they are believed to be less susceptible to injury during the more natural hours. This third shift should be reserved for proper inspection and maintenance of machinery.

Locomotive v. Truck Haulage in Bituminous-Coal Strip Mines

This subject is interesting to both the coal and open-pit ore operators.

Haulage operations were studied at 11 mines in Illinois, 10 in Indiana, 5 in Missouri, 4 in Kansas, 1 in Oklahoma, and 1 in Kentucky, 32 in all.

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Three types of haulage were observed:

1. Motorized haulage from loading shovel to tipple.
2. Rail haulage from loading shovel to tipple.
3. Dual haulage - motorized haulage from loading shovel to a transfer station and rail haulage from this station to the tipple.

The results of this study show that at present motorized haulage in mines has an advantage over rail haulage when the distance does not exceed 2.7 miles per round trip. The length of motorized haul should be kept as short as possible - under 2.7 miles round trip - and beyond this point rail haulage should be used to the tipple, where the topography permits the construction of a railroad at a reasonable cost. The mining of isolated areas of coal where the topography is rough and the cost of constructing a railroad into such an area would be prohibitive has been made possible by the use of motorized haulage. Motorized units can negotiate grades that would not be practical for rail haulage. Although operating costs for motorized haulage would exceed rail-haulage costs under these conditions, investment for rail transportation would offset this advantage. The mining of these isolated areas adds greatly to our recoverable mineral resources.

Publications

The following papers were published during the year:

I.C. 6949 - Shaft- and Slope-Bottom Lay-Outs at Coal Mines, by Robert L. Anderson. 39 pp.

I.C. 6959 - Some Aspects of Strip Mining of Bituminous Coal in Central and South Central States, by Albert L. Toenges and Robert L. Anderson. 87 pp.

I.C. 7014 - Multiple-Shift Mechanical Mining in Some Bituminous-Coal Mines. Progress Report 1, by Albert L. Toenges and Robert L. Anderson. 56 pp

Mining Methods in the Grundy Field, Virginia, by Albert L. Toenges and Robert L. Anderson (I.C. 6928 reprinted in Explosives Engineer, vol. 16, no. 5 May 1938, pp. 131-137, in part; vol. 16, no. 6, June 1938, pp. 177-180, complete).

MINERAL INDUSTRIES SURVEY SECTION

C. E. Julihn, Supervising Engineer

A study was made of the southern part of the Mother Lode of California in Calaveras, Tuolumne, and Mariposa Counties. A general preliminary survey and field work in Calaveras County were completed by the end of the field season of 1937. The results are contained in Bulletin 413, which was issued in August 1938.

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All mines of the county were visited, and many of them were discussed individually. The chief objective, however, was broad generalization as to the nature of mineral deposits of the region and as to mining possibilities that remain for the future. Special attention was given to a study of drift mining with gold at $35 per ounce, and the potentialities for expansion of this type of placer mining by using modern equipment and the latest mechanized mining methods are discussed in the bulletin.

Field work was completed in Tuolumne and begun in Mariposa Counties. A second bulletin, covering these two counties, will complete the project.

Mining on the southern section of this great lode has received far less attention in technical literature than that of the northern section. Since conditions in the southern section are not as well understood, an attempt has been made to provide for the use of operators a readable account of the region to serve as background for mine reports on individual properties.

MINE VENTILATION SECTION

G. E. McElroy, In Charge

Mine Ventilation Field Studies

Tentative plans were made for assisting a large coal company in initiating a system of absolute-pressure surveys of ventilation systems in its Alabama coal mines. Such surveys readily determine how mine-ventilation systems can be improved most economically. Actual demonstrations are desirable for encouraging a wider use of the method in United States coal mines.

I.C. 6965, Ventilation at the Anthracite Collieries of the Northern Pennsylvania Field, by G. E. McElroy, 23 pp., based on 1933-34 field studies but not approved by the operators until May 1937, was published in November 1937. Both the field work and the paper have revived a long-dormant interest in improvement of mine-ventilation practices throughout this field.

Mine-Ventilation Research

Work on this problem consisted mainly in formulating plans for future work and assisting others in analyzing the results of research in allied fields. A week was spent in the East Tintic district, Utah, considering plans for a survey to determine the relation of rock temperature to ore deposition in that district. The facilities offered by mining companies were too limited, however, to make such a survey feasible. A short study was made in New York City of special ventilation problems involved in subway and under-river tunnel construction.

A mathematical investigation of the effect of leakage in fan-pipe lines on fan-performance requirements was the subject of a study. Solutions were found, which, though too complex for direct use, may lead eventually to a tabular or graphic form suitable for general use and for replacing the present guesswork in selecting fans for auxiliary ventilation in mines and tunnels.

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Anthracite-Mine Fires

In cooperation with company officials and the Health Division, an outline for conducting fire-hazard surveys in the mines of the Philadelphia & Reading Coal & Iron Co. was prepared and printed in booklet form by the company. This outline was then used by the Health Division in surveying the company mines and is available for similar work elsewhere. A résumé of the results of field work to date was published in June 1938 as Information Circular 7025, Some Observations on the Causes, Behavior, and Control of Fires in Steep-Pitch Anthracite Mines, by G. E. McElroy (36 pp.)

Field work on recent fires has been handled mainly by field men of the Health Division, and laboratory work has been continued by the Explosives Division. Close contact has been maintained with the work of both by means of frequent conferences and discussions. Special consideration was given to the possibilities of dry ice in combatting fires, and important investigations are under way on the effect of bacteria on the carbon monoxide content of sealed fire areas. Work on this problem has required about 14 percent of the time of the section.

Air-Conditioning in Mines

The major activity of the section throughout the year was a close study of available records on the application of mechanical refrigeration to mines and accounted for approximately 40 percent on a time basis. Results from the only two installations in the United States - at Butte, Mont., and Superior, Ariz. - were checked during a 1-month field trip in August 1937 and by correspondence. On the field trip, the possibilities of installing a system were discussed with the officials of a hot mine at Dividend, Utah. During the year information became available on the results of foreign installations, mainly in South Africa, and these were analyzed carefully. To date the study shows that the successful application of air-conditioning to mines is largely a question of proper air distribution rather than selection of mechanical equipment. The two large problems are preserving the coldness of the air in transit from the point of generation to the actual working places, and getting the abstracted heat out of the mine. The actual cooling of the air is only a relatively minor phase of the problem of mine application. The transportation of cooled air depends largely upon the interaction of rock and air temperatures, for which mathematical solutions are so complex and time-consuming as to be almost impracticable, and direct experimental data are more desirable. Arrangements for removing the abstracted heat from the mine add greatly to the difficulty and cost of underground installations, and the economics of various arrangements must be determined by actual trials.

The study has progressed to the point where the meagerness of useful data in the voluminous publications on this subject is fully realized, a point that will be stressed in a paper being prepared for publication and will comprise a résumé of the present knowledge of this subject.

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ELECTRICAL-MECHANICAL SECTION

L. C. Ilsley, In Charge

Introduction

At the beginning of the fiscal year the study of mechanical mining equipment, with particular reference to efficiency, care, and safety in use, was added to the work of investigating electrically operated mining equipment as related to the hazard of gas and dust ignitions. The name of the Electrical Section accordingly was changed to Electrical-Mechanical Section.

As in former years, the electrical investigations comprised principally examinations and tests of devices and equipment submitted by manufacturers who have requested that the Bureau of Mines grant approval of their product. The approval of such devices and equipment is contingent upon compliance with minimum standards or requirements for safety as specified in publications known as schedules, of which the following are now in force:

Schedule 2D - Explosion-Proof Mine Equipment.
Schedule 6C - Permissible Electric Cap Lamps.
Schedule 7C - Flame Safety Lamps.
Schedule 8C - Portable Methane Detectors.
Schedule 9A - Procedure for Establishing a List of Permissible Telephones for Use in Coal Mines.
Schedule 10B - Miscellaneous Portable and Semiportable Electric Mine Lamps.
Schedule 11A - Permissible Electric Flashlights.
Schedule 12B - Single-Shot Blasting Units.
Schedule 16A - Multiple-Shot Blasting Units.

At present, no tests of mechanical appliances are contemplated and no schedules have been prepared, the problem being confined to the collection of pertinent information as to using and operating mining machinery and to making safety recommendations tending to the reduction of mechanically caused accidents.

Both electrical and mechanical investigations were carried on by last year's staff, comprising nine engineers, one laboratory aid, and a clerk. Two engineers gave part time toward gathering data relating to mechanical safety problems.

The year was marked by a large increase in number of devices and machines approved, the total being 37, or 42 percent above that of last year. Several new types of equipment were included in this total, namely (1) a multiple-shot generator blasting unit, the first approval issued under Schedule 16A; (2) a self-propelled caterpillar truck for transporting mining machines or other equipment; and (3) two slate-cutting machines, each operated by a 100-horsepower motor. For many years a 50-horsepower motor was considered near the maximum rating that could be built for satisfactory operation with explosion-proof enclosures. It is believed that greater safety in blasting was made

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possible through the approval of several low-cost single-shot blasting units placed on the market during the year to compete with nonapproved devices.

That Bureau of Mines-approved equipment is valued highly in foreign countries is indicated by the fact that customers in Australia, India, Canada, and South Africa insist that the machines ordered bear the Bureau of Mines approval plate.

A study of fuels for flame safety lamps resulted in the drafting of tentative specifications under which it should be possible for mine operators to procure a fuel that will burn with a steady, clear, smokeless flame. This should eliminate some of the unsatisfactory behavior of lamps that has resulted from the promiscuous use of motor gasolines and other unsuitable fuels.

Approval Work for Fiscal Year 1938

Under Schedule 2D

The products of 11 manufacturers were approved under Schedule 2D during the year, including 8 coal-cutting machines, 2 slate-cutting machines, 4 loading machines, 11 conveyors, 1 caterpillar truck, 1 room hoist, 1 mine pump, and 1 rock-dust distributor. The 29 machines were equipped with 131 explosion-proof enclosures, involving many explosion tests and the careful inspection of parts in addition to close examination of a great many blueprints and specifications to determine whether the minimum requirements of Schedule 2D had been met in the construction of these machines.

Changes in Approved Machines

Numerous changes in machines already approved were officially authorized by extension of original approvals upon satisfactory completion of inspection and test of modified parts or, when tests were not required, upon submission of satisfactory revised drawings and specifications, which were carefully reviewed and checked against those on record for the original approval.

Investigation of Explosion-Proof Parts for Incorporation in Permissible Machines

A number of electrical manufacturers do not build complete machines for mining service but do make explosion-proof parts, such as motors, starters, and headlights, that may be used in assembling a permissible machine. Some of these electrical manufacturers have a line of motors of suitable ratings to meet many of the requirements of permissible machine builders, who, therefore, are thus relieved of designing and constructing motors. The Bureau's part comprises the inspection and test of such motors and other parts. For those found to comply with the constructional requirements stated in Schedule 2D, the Bureau issues "letters of suitability", which permit the manufacturer to offer his product to builders of permissible machines with the assurance that further inspection and test of the motor or other specified part will

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not be required. Letters of suitability were issued for 11 direct-current motors, 6 alternating-current motors, 2 alternating-current starters, 2 direct-current starters, 2 junction boxes, 2 headlights, 1 headlight resistor box, and 1 control station, and extensions were also issued to allow additional optional ratings and variations in construction.

Under certain conditions, the wiring and parts within explosion-proof enclosures are subject to nitric acid corrosion as the result of the enclosed atmosphere being broken down by electric flashes at contactors. Several manufacturers are attempting to remedy the condition by the use of "breathers" or vents that will permit the circulation of air through the enclosure without permitting flame to pass through and out of the vents. In all, 1,535 explosion tests were made in gallery 5 with vents of various designs of four manufacturers, and several designs had to be modified three or four times before they were successful in preventing escape of flame.

Approval of Electric Lamps and Flashlights,

Schedules 6C, 10B, and 11A

Investigation of lamps during the fiscal year resulted in the approval of one hand lamp under Schedule 10B and one flashlight under Schedule 11A. A number of modifications in permissible electric cap lamps, signal lamps, and flashlights were examined and approvals were extended to allow the proposed modifications.

Flame Safety Lamps,

Schedule 7C

No approvals were issued under this schedule; however, examination and tests of modified permissible lamps resulted in extensions of approval being granted to the manufacturers to cover the modifications.

Safety-lamp fuels submitted by six oil companies were investigated, and, on the basis of this investigation, tentative specifications for a satisfactory lamp fuel were drafted. The results of this investigation were published in Report of Investigations 3389, Fuel for Permissible Flame Safety Lamps. The product of four companies was found to meet specifications. Fuels that do not meet these specifications are likely to cause the lamp to burn with flickering or smoky flame and may corrode the lamp parts.

Electric Shot-Firing Devices

Schedules 12B and 16A

Although permissible single-shot blasting units have been on the market for years, the high initial cost and the cost of maintenance have restricted their use by miners who were required to purchase their own shot-firing devices. Consequently, many cheap, nonapproved devices, which the Bureau regards as being unsafe, have been used instead. Therefore, the Bureau has encouraged

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the development of inexpensive dry-cell blasting units in the hope that the nonapproved types will be largely or entirely displaced, and during the year five single-shot dry-cell units were approved under Schedule 12B.

Under certain conditions of mining it may prove to be less hazardous to fire several shots simultaneously instead of singly. In recognition of this, Schedule 16A, giving the requirements under which multiple-shot blasting units would be approved, was issued in March 1937. The first approval was granted this year under its provisions and covers a generator type of 10-shot capacity.

Field Work

During the year 32 visits were made to factories to inspect permissible equipment in course of construction and to confer with manufacturers' engineers or representatives in assisting them to design permissible equipment.

Mining Machinery and Mechanical Safety

In the study of mechanical hazards associated with the operation of machinery in mines, visits were made to 14 factories and manufacturers' representatives, 21 mines and mine headquarters, and the mechanical engineering departments of two universities. As a result of these visits many data on the following subjects were collected:

1. The manufacture, inspection, and care of hoisting ropes for mine shafts and slopes. A paper on this subject is in preparation.
2. The practicability and use of guards for the cutter bits of mining machines. A paper on this subject was delivered at the December 9 meeting of the Coal Mining Institute of America in Pittsburgh by the supervising engineer.
3. The application of skids, brakes, automatic mine-car couplers, and other devices for reducing haulage accidents in mines.

Visual Lessons in Safety

Since July 1, 1937, more than 280 persons, including students, mining engineers, and manufacturers' representatives, have visited the Electrical Laboratory, where the approval system has been explained and demonstrations given to show how electric sparks and flashes may ignite methane in a coal mine. These demonstrations are made with 10 glass-walled chambers, each one containing a different device representative of a hazardous condition that may exist underground, and in each instance it is pointed out how the hazardous condition may be remedied by the use of equipment approved by the Bureau of Mines.

State Safety Codes

A complete file of State mining laws and safety codes pertaining to mining is kept for reference and study in the Electrical-Mechanical Section.

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These were examined with reference to two special subjects during the year and manuscripts for Bureau publication were prepared. The first of these deals with legal restrictions placed by existing codes upon the use of Diesel engines and locomotives in mines. The second deals with limitations imposed upon the speed and number of men that may be hoisted or lowered in mine shafts.

Committee Work

The supervising engineer of the section has kept in contact with progress in safety work in electrical engineering by membership in the following committees: The Technical Committee on Mine Lighting of the International Commission on Illumination; the American Institute of Electrical Engineers. Committee on Applications to Mining Work; the American Institute of Electrical Engineers Mining Correlating Committee; the National Fire Prevention Association Committee on Static Electricity, the Underwriters' Electrical Council, and Sectional Committee for the revision of the National Electrical Safety Code.

Miscellaneous

Conferences were held with representatives of the Navy Department, both in Pittsburgh and Washington, D. C., regarding cooperation between that Department and the Bureau in giving them assistance in drafting specifications for electrical equipment to be used on naval vessels where gasoline vapors may be present. This assistance also included the inspection and test in the Electrical Laboratory of six devices in explosive atmospheres containing gasoline vapors. The explosion tests of these devices totaled 251.

Publications

The following publications were issued:

R.I. 3359 - Permissible Methane Detectors, by L. C. Ilsley and A. B. Hooker. 4 pp.

R.I. 3363 - Permissible Electrically Operated Hand-Held Coal Drills, by L. C. Ilsley, E. J. Gleim, and H. B. Brunot. 13 pp.

R.I. 3389 - Fuel for Permissible Flame Safety Lamps, by A. B. Hooker and E. J. Coggeshall. 5 pp.

R.I. 3391 - Permissible Electrically Operated Post Drills and Drilling Machines, by L. C. Ilsley, E. J. Gleim, and H. B. Brunot. 17 pp.

I.C. 6981 - Coal-Mine Fires of Electrical Origin: Their Cause and Prevention, by E. J. Gleim. 17 pp.

I.C. 7007 - List of Permissible Mine Equipment Approved During 1937, by L. C. Ilsley. 4 pp.

I.C. 7011 - Fatal and Nonfatal Electrical Accidents In Coal Mines, by L. C. Ilsley. 7 pp.

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